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TITLE OF THE INVENTION

P-TYPE SEMICONDUCTOR AND SEMICONDUCTOR HETERO MATERIAL
AND MANUFACTURING METHODS THEREOF

5 BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a p-type semiconductor and particularly to a p-type semiconductor with low resistance.

10 (2) Description of the Related Art

In recent years, a nitride semiconductor based on gallium nitride has been commercially utilized for a full color display, a blue (long wave ranged from ultraviolet to yellow) light-emitting diode used for a signal light and the like, a write/read apparatus for optical
15 recording media and blue laser used for a laser microscope and the like. Further, the nitride semiconductor is expected to be applied to media which enables high-density record and white light source which uses no mercury. Additionally, since an oxide semiconductor based on zinc oxide has a band gap of 3.37 eV at room temperature,
20 resistance to reducing gas, stability at a high temperature, and excellent transparency, it is expected to be applied to a transparent conductive film and like besides the above-mentioned media which enables high-density record, although it is not yet commercially utilized.

25 There are some problems to realize and spread these technologies. The biggest problem is to realize a p-type semiconductor with low resistance. To lower the resistance of a p-type semiconductor, it is necessary to increase hole carriers in a valence band which contribute to conduct electricity. To increase
30 the hole carriers in the valence band, it is general practice to dope an acceptor dopant. However, an acceptor level of a nitride semiconductor used to realize these technologies is formed at a